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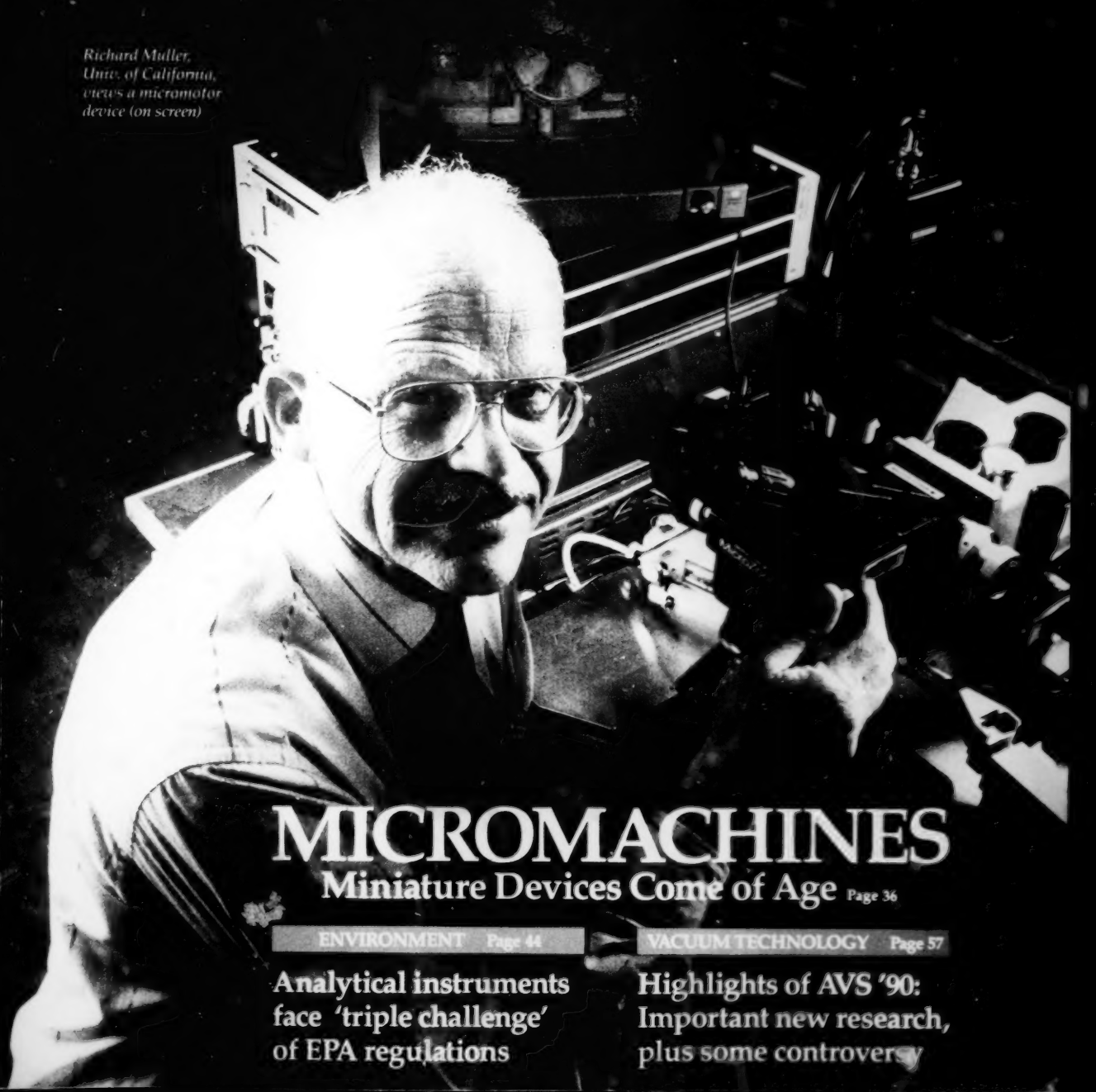

Richard Muller, Univ. of California, views a micromotor device (on screen)

MICROMACHINES

Miniature Devices Come of Age Page 36

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Analytical instruments face 'triple challenge' of EPA regulations

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Highlights of AVS '90: Important new research, plus some controversy

INTERNATIONAL MAGAZINE OF RESEARCH AND DEVELOPMENT

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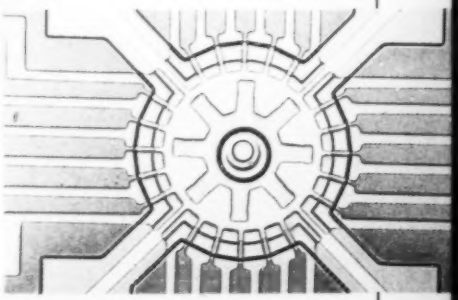
This year's AVS Symposium in Toronto was chock full of new developments and controversy. AVS '91 in Seattle promises more of the same.



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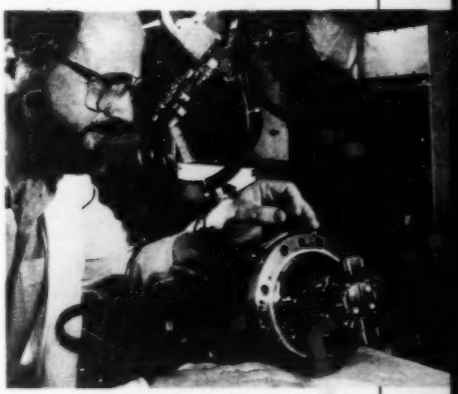

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Japan struggles to build basic research efforts

JAPAN'S BASIC RESEARCH expenditures grew from $8.3 billion in FY87 to $8.6 billion in FY88, a 3.6% increase. In the same period, applied research spending grew 8.3% and developmental research grew 9.9%, according to Japan's latest government survey.

Unfortunately for those Japanese researchers wishing to impress upon the world that they are sincere about becoming a source of basic research knowledge, the portion of Japan's total R&D expenditures devoted to basic research fell from 14% in FY87 to 13.3% in FY88.

Japanese industry's commitment to commercial development continues to dominate the nation's R&D spending, rising from $25.9 billion (60.6%) in 1983 to $40.3 billion (62.4%) in 1988.

Basic research in Japan is in gradual decline in many areas. Even university- and research institution-funded basic research had smaller shares of the total R&D spending in 1988 than in 1987. Basic research in universities fell from a 54.2% share of their total research in 1987 to a 52.8% share in 1988. In Japanese research institutions, basic research fell from a 15.8% share in 1987 to 14.9% in 1988.

Japan's Human Frontiers Science Program (HFSP) typifies its problems with basic research programs. HFSP, a 20-year international program to explore basic biological functions, was proposed by Japan in 1986. Japan committed to pay up to half the $6.7 billion cost, but funding was delayed by the government until FY89.

Even after Japanese funding was approved, which amounted to 35% of the international commitment, Japanese researchers were awarded only 5% of the basic research work.

—Tim Studt

Report lists more than 250 new applications for laser technology

FROM MEASURING THE concentration of cow methane in a field to sizing and possibly even controlling the formation of tornadoes, many new market opportunities exist for emerging laser systems, according to a report by William Truett, president of Truett Scientific Co., West Brattleboro, VT.

More than 280 current applications and more than 250 new applications in 32 different areas are listed in the study.

In one potential application, the methane concentration in a field filled with cows could be measured precisely with a CO_2 gas laser or lead-acid salt-tuned laser diodes.

LADAR (laser detection and ranging) systems currently are the only operational systems for detecting turbulent air. High-powered airborne CO_2 or Nd:YAG laser systems, however, could control the formation of some turbulent air systems, such as tornadoes, according to Truett.

For a copy of *New & Emerging Laser Applications, A Technical Forecast* ($495) call 802/257-9409. □

Researchers get free access to funding sources

RESEARCHERS AND TEACHERS in nonprofit institutions can obtain free access to a database listing public and private funding resources for the purchase of laboratory equipment in a program made available by Spectra-Physics, San Jose, CA.

The database lists the sources, addresses, deadlines, and application procedures for obtaining grants to purchase chromatography and electrophoresis instruments and chromatography data management systems.

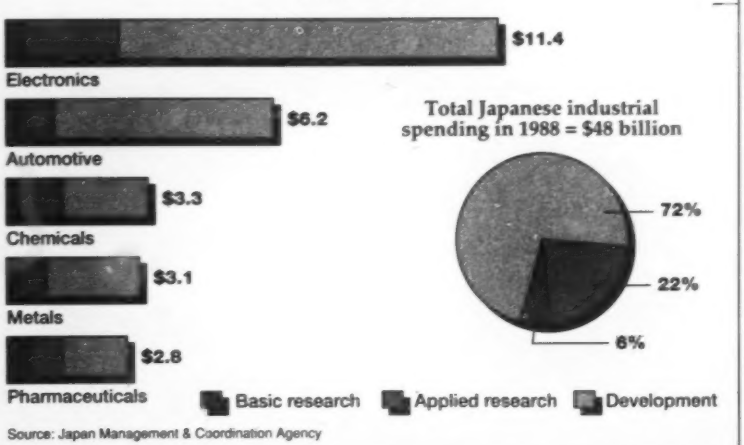
continued

Mass spectrometers to grow 13% annually

Worldwide sales of mass spectrometers (not including GC-MS or LC-MS) are forecast to grow nearly 13% annually through 1993 to $430 million, according to Strategic Directions Intl., a Los Angeles-based market research firm.

Currently, U.S. and Canadian sales account for more than 50% of the world market for mass spectrometers. This number will decrease as the European market grows because of increasing environmental concerns.

Japanese industries focus on the 'D' in R&D
(in billions)



Source: Japan Management & Coordination Agency

Japanese chemical, metals, and pharmaceutical firms spend 7% to 19% of their R&D budgets on basic research, while automotive and electronics firms spend less than 5%.

Environmental Instruments Meet a Triple Challenge

Researchers are coming up with new analytical instruments that are fast, simple to use, and extremely reliable.

*By **Tim Studt**, Associate Editor, R&D Magazine*

R&D Perspectives

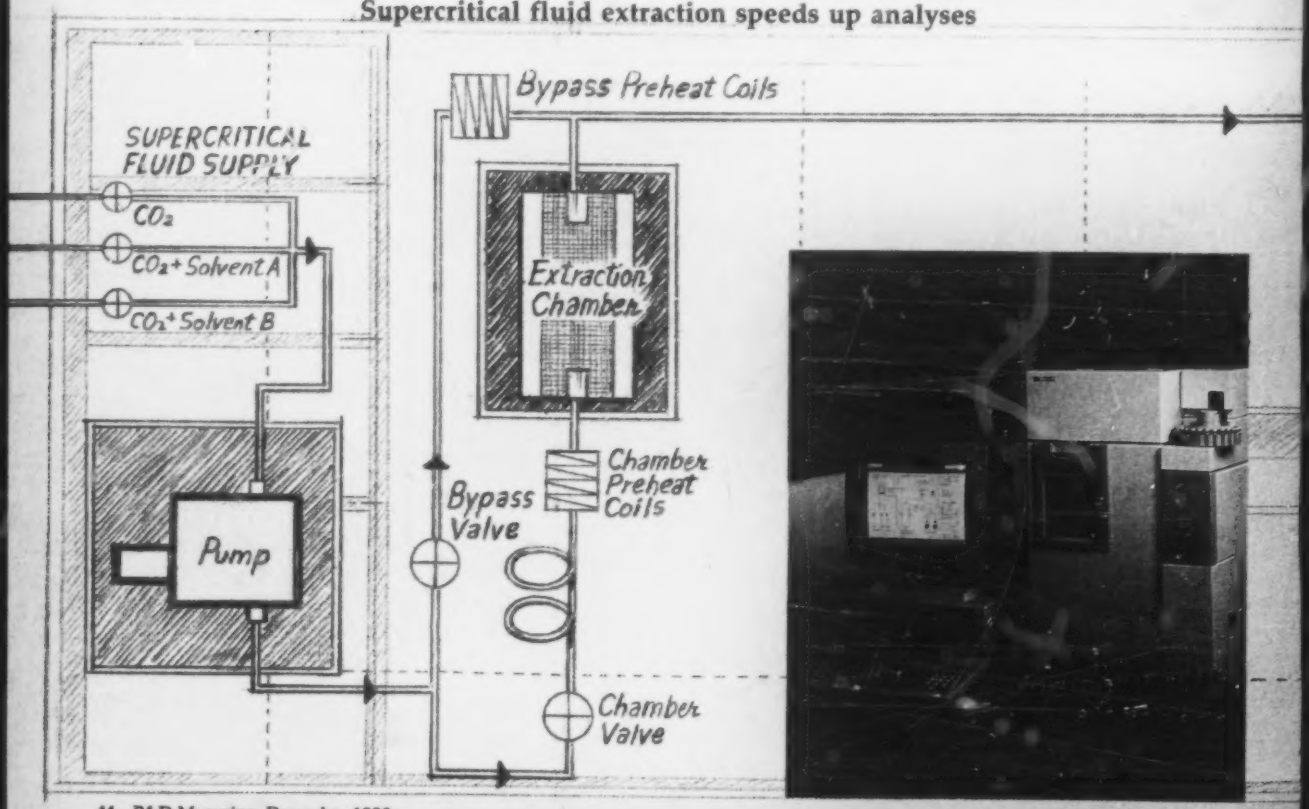
RESEARCHERS CHARGED with producing new instruments to monitor the environment face three obstacles: speed, simplicity, and reliability.

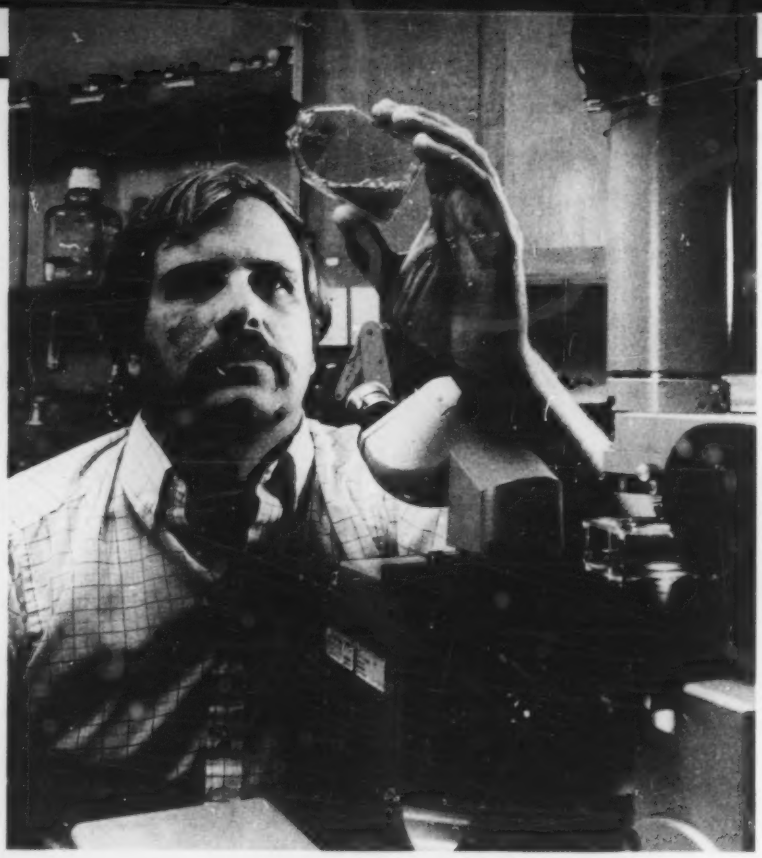
They need to make instruments that shorten the time needed for analysis, make it easy to perform tests in the field, and operate reliably. If the instruments also can measure some previously unknown threat to the ecosystem, that's a bonus.

Instrument makers are meeting the triple challenge of speed, simplicity, and reliability with new devices in four key areas:

- **supercritical fluid extraction,** a faster system for sample preparation
- **environmental immunoassay,** a test procedure for quickly screening samples in the field
- **an improved GC-MS system** that meets U.S. Environmental Protection Agency (EPA) methodology and keeps on running

Supercritical fluid extraction speeds up analyses





Marty Vanderlaan, a scientist at Lawrence Livermore (CA) National Laboratory holds a flask of monoclonal antibodies used to screen for dioxins.

- **an ion-assisted system** that reliably measures short-lived OH radicals.

When characterizing an air, water, or soil sample for environmental purposes, you have to extract specific compounds from the sample before it can be injected into an analysis system, such as a gas chromatograph, liquid chromatograph, or nuclear magnetic resonance instrument.

You could use conventional extraction techniques, such as soxhlet extraction or liquid-liquid extraction, but they require a lot of time and labor.

Taking faster samples

Supercritical fluid extraction (SFE) offers substantial time and labor savings over these techniques.

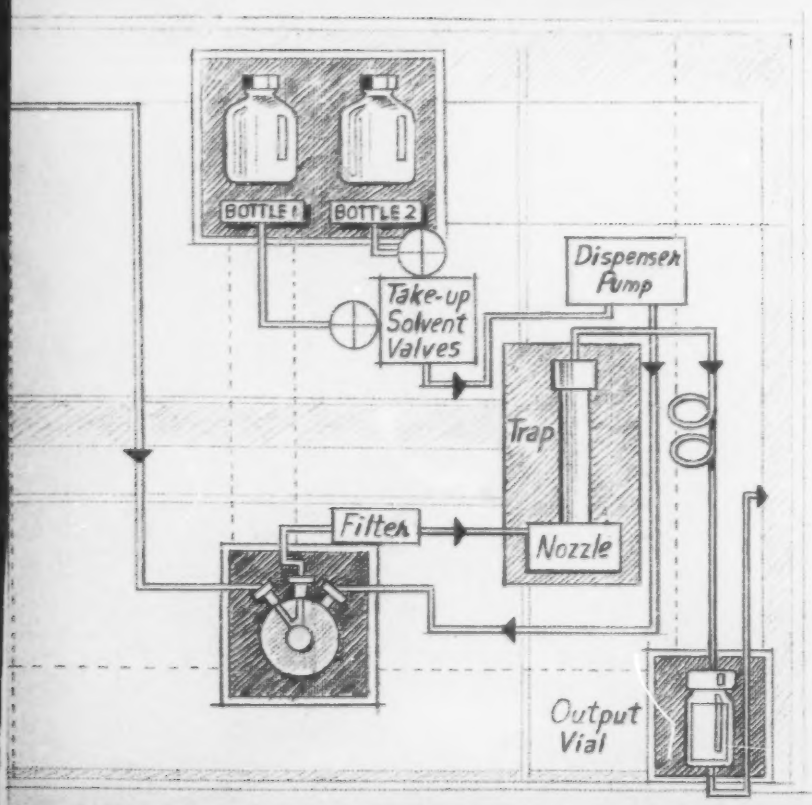
"An EPA soxhlet procedure that requires 18 hours to complete can be done in about 15 minutes with SFE," says Stuart Cram, a federal programs manager at Hewlett-Packard, Palo Alto, CA. "Liquid-liquid extraction techniques requiring 36 hours can be done in 20 minutes with SFE."

SFE can be used for extraction of analytes, such as PCBs, pesticides, and herbicides from soil, sludge, and animal and vegetable tissue. Besides saving time, SFE eliminates the need for the hazardous chlorinated solvents used in other extraction methods.

SFE instruments use CO_2 to perform the extraction. This allows you to extract nonpolar compounds, but makes it impossible to measure polar and/or ionic compounds.

Researchers have found that adding 1% to 3% methanol to the CO_2 allows you to extract more compounds. They still need to develop the methods for quantitatively controlling the doping of methanol, a liquid, to CO_2, a gas.

Researchers at Lawrence Livermore (CA) National Laboratory (LLNL) have developed a series of monoclo-



***Carbon dioxide** is used as the solvent in this supercritical fluid extractor (inset and schematic) because of its ease in creating a supercritical CO_2 state, low boiling point, and nontoxicity. The large extraction samples in the autosampler vials can be transferred and injected into gas, liquid, or supercritical fluid chromatographs for analysis.*

Environmental immunoassays can be used to screen samples for dioxins and insecticides in the field.

nal antibody test procedures, or immunoassays, that can be used to detect the presence of pesticide residues, mycotoxins, and industrial chemicals.

Just as blood samples can be tested for the HIV factor or drugs, environmental immunoassays can be used to screen samples for trace residues in the field. If samples test positive, they then can be sent for full laboratory analysis.

Immunoassays also can measure compounds that are not measurable by other means, such as pyrethroids—a class of insecticides not monitored because they are not measurable by conventional means.

LLNL researchers have developed monoclonal anitbodies for dioxin, cyclodiene insecticides, pyrethroid insecticides, and dimetridazole, a veterinary drug.

Immunoassay systems also can be used quantitatively. "When combined with HPLC (high-performance liquid chromatography), our immunoassays can offer a 1,000-fold increase in sensitivity over HPLC-UV systems," says Martin Vanderlaan, a chemist at LLNL.

Improving reliability

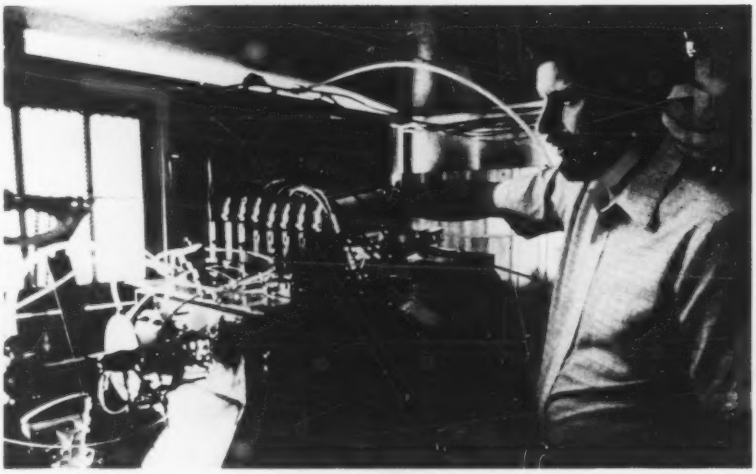
EPA's test method 625 requires measurement down to the parts-per-billion range in chemical sampling. Most GC-MS systems can measure to these levels, but you have to shut them down after five to 10 days for maintenance, which itself takes a day or two.

Then there is EPA method 525, which has a limit of 400 parts per trillion (ppt). A few instruments can measure to this level, but you have to shut them down for maintenance after only 12 hours of use.

Researchers at Oak Ridge (TN) National Laboratory (ORNL) have developed a GC-MS system with 100-ppt accuracy that they have run continuously for more than six months.

"We've corrected the front end so what you put in at the GC is now delivered to the mass spectrometer," says ORNL chemist Quirinus Grindstaff.

Researchers at Georgia



Fred Eisele, a scientist at Georgia Tech, Atlanta, uses this mobile ionization instrument to measure the amount of short-lived OH radicals in the atmosphere.

The environmental market: diversity and growth

THE MARKET FOR analytical instruments used to assess environmental conditions should grow more than 14% annually, to $2.25 billion in 1994, according to Strategic Directions Intl., a Los Angeles-based market research firm.

When taking inflation into account, this growth is nearly double that forecast by the U.S. Dept. of Commerce for analytical instruments in general.

Environmental instruments can be grouped into those used in laboratories, such as chromatographs, mass spectrometers, and atomic spectroscopy products, and those used in the field, such as source analyzers and radiation detectors.

"Non-laboratory instruments used for air analysis have the largest growth forecast (+21%) because much of the emphasis on environmental regulations worldwide is toward air quality, and these instruments are growing from a relatively small base," says SDI president Lawrence Schmid.

The best-selling categories of the combined environmental instruments market are those used for water analysis (58% of the total in 1989) and air analysis (12%). By 1994, water analysis instruments will have 60% of the total, air analysis instruments 12%, says Schmid.

The biggest customers for environmental instruments are government agencies, independent test labs, and energy and water utilities, consuming 58% of all such sales in 1989.

After running for more than six months, a new GC-MS still measures down to 100 parts per trillion.

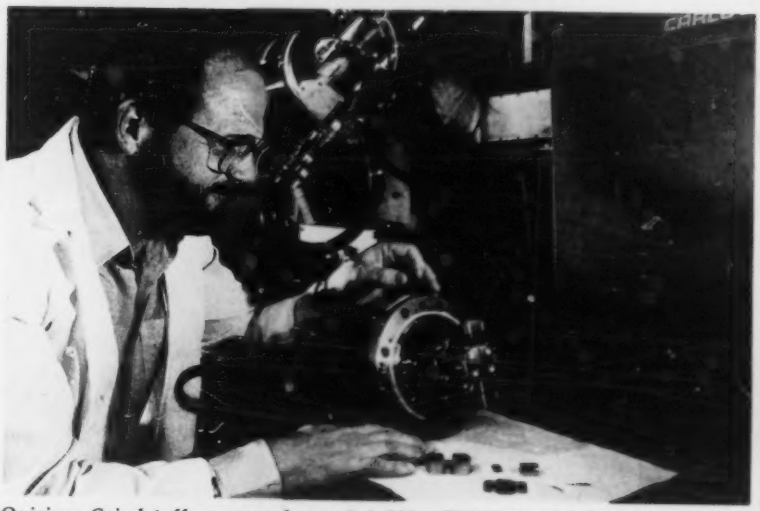
Tech Research Institute, Atlanta, have developed a technique that measures the amount of OH radicals in the air.

OH radicals remove pollutants in the atmosphere, such as methane, carbon monoxide, and certain halocarbons. If OH levels are changing, the CFC replacement halocarbons could be worse for the atmosphere than the CFCs are for the ozone layer.

New OH radicals are generated every day by sunlight reacting with ozone in the air. They survive for about one second before reacting with other compounds.

Given OH's short life, scientists find it difficult to determine if OH radicals are decreasing or increasing. Conventional techniques for measuring OH, such as optical long-path absorption, are cumbersome and unreliable.

Fred Eisele, a principal research scientist at the Georgia Tech lab, accidentally discovered a way to determine OH levels as he was measuring ions being formed under high-voltage power lines.



Quirinus Grindstaff, a researcher at Oak Ridge (TN) National Laboratory, examines a GC-MS system that samples down to 100 parts per trillion with little maintenance.

He noticed that the rise and fall of mass spectrometer signals for sulfuric acid ions corresponded to changes in incident sunlight. Eisele realized that sulfuric acid was being produced in correlation to the production of OH.

He developed a system that injects nitrogen and sulfur dioxide into ambient air samples. These gases then ionize to create sulfuric and nitric acids. "Using the reaction rates and times involved, we can measure the amount of OH radicals in the initial sample," says Eisele.

This ion-assisted system can measure OH at 1×10^5 molecules/cm^3, several decades lower than other systems. Additionally, by having a different methodology, it can be used to compare results with other systems.

Stuart Cram describes SFE as a system with "high demand, high anticipation, and a very high need." With ever increasing environmental problems, you can say the same of GC-MS, environmental immunoassay, and OH instruments. **R&D**

Common techniques for measuring the environment

Matrix	Analyte	Instrument technique
Drinking water and wastewater	Organic compounds	Gas chromatography
		Gas chromatography-mass spectrometry
		Liquid chromatography
		Fluorescence
	Metals	Atomic absorption
		Graphite furnace atomic absorption
		Inductively coupled plasma emission
		Inductively coupled plasma-mass spectrometry
		Ultraviolet/visible spectroscopy
	As, Se, Hg, N, P, cyanide, fluoride, sulfate, phenolics, chloride	Mercury/hydride atomic absorption
		Ultraviolet/visible spectroscopy
	TOC	Organic elemental analysis systems
Solid waste	Organic compounds	Gas chromatography
		Gas chromatography-mass spectrometry
		Liquid chromatography
	Metals	Atomic absorption
		Graphite furnace atomic absorption
		Inductively coupled plasma emission
		Inductively coupled plasma-mass spectrometry
Air	Organic compounds	Gas chromatography/thermal desorption
		Gas chromatography-mass spectrometry
		Organic elemental analysis systems
	Metals	Atomic absorption
		Graphite furnace atomic absorption
		Inductively coupled plasma emission
		Inductively coupled plasma-mass spectrometry

Source: Perkin-Elmer

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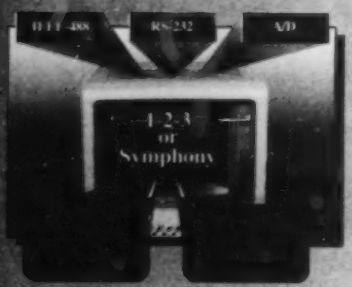

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